Tagliamento river high valley (Italy)

Situation of the valley

The study area near Tolmezzo city (s.l.m. 270-340m) is located close to the hypocenter of the 1976 M=6.4 Friuli earthquake and is characterized by medium strong earthquakes mainly due to blind thrust faults extending from East to West. The valley has an alluvial (U) shape with a maximum width of about 2200m and the thickness of quaternary deposits is greater than 200m. Tagliamento river high valley (THV) is the result of numerous glaciations processes and erosive processes alternatively due to glacial and fluvial actions. Today, most of the valley on the right part of the river is characterized by alluvial terraces, several tens of meters high. THV is underlain by unconsolidated alluvial material of quaternary age. This material consists primarily of coarse gravel and cobbles with coarse-grained sand. Also, silt and clay occurs under the older flood plain located adjacent to Cavazzo Carnico. The surrounding mountains and foothills are formed from dolomite and dolomitic limestone of Triassic and Jurassic Age. The other geologic formations such as alluvial outwash deposits, fan deposits, and talus deposits are composed of detritical rock fragments and blocks from the adjacent Dolomite Mountains.

Figure 1: THV and Tolmezzo city view from Strabut Mount

State of art of the instrumentation and measurements in the valley at the beginning of the project

No knowledge of geophysical properties of soils at depth and no information on the sediment-bedrock interface shape was available. The following existing measurements were collected at an early stage of the project:

- 59 shallow geotechnical surveys
- 36 standard penetration test
- 10 shallow seismic refraction soundings
- Some geological maps and studies

From these studies and measurements it was possible to constrain only the shallow soils up to the depth of 15 m. Since the hypothesized valley depth exceeded 200 m the sediment alluvial cover and valley shape were poorly constrained before the project.

Instrumentation and measurements realised in the valleys during the project

During SISMOVALP project the following measurements were realised to improve our geophysical knowledge of the valley and evaluate the seismic response:

- 6 seismic stations were deployed, during a 18 months periods, across the valley along a transect from Cavazzo Carnico to Amaro municipalities to record local weak earthquakes in order to apply a classical spectral ratio technique,
- 250 points of horizontal to vertical (Nakamura) spectral ratio noise analysis to define the fundamental frequencies of resonance within the valley,

- 3 shear wave velocity profiles up to the depth of 120-150m from the analysis and inversion of the surface waves - inverted profiles were constrained to satisfy the spectral ratio noise measurements,
- 266 micro gravimetric measurements in the valley and surrounding hills.

The techniques used in the framework of the project were selected in order to have a fast and cheap data acquisition stage and to allow at the end, via appropriate data integration, the setup of a preliminary 3-D geophysical model.

Results of the work done in the valley

Sorting of the spectral ratios of the ambient noise measurements in subzones showed that there is a certain spatial stability and smoothness in the variations (Fig. 2). We tried to pick and map the first low frequency peak in the band from 0.5 to 2.0 Hz in order to estimate a possible geometric variation of the bedrock due to the shape of the valley. Although the stability of the H/V measurements, the shape of spectral ratios is generally complex with multiple peaks and sometimes the ratio is quite low. Moreover there is a strong effect of the wind, during noise acquisition, for frequencies below 1 Hz. Thus to better interpret H/V spectral ratios other independent measurements were needed.

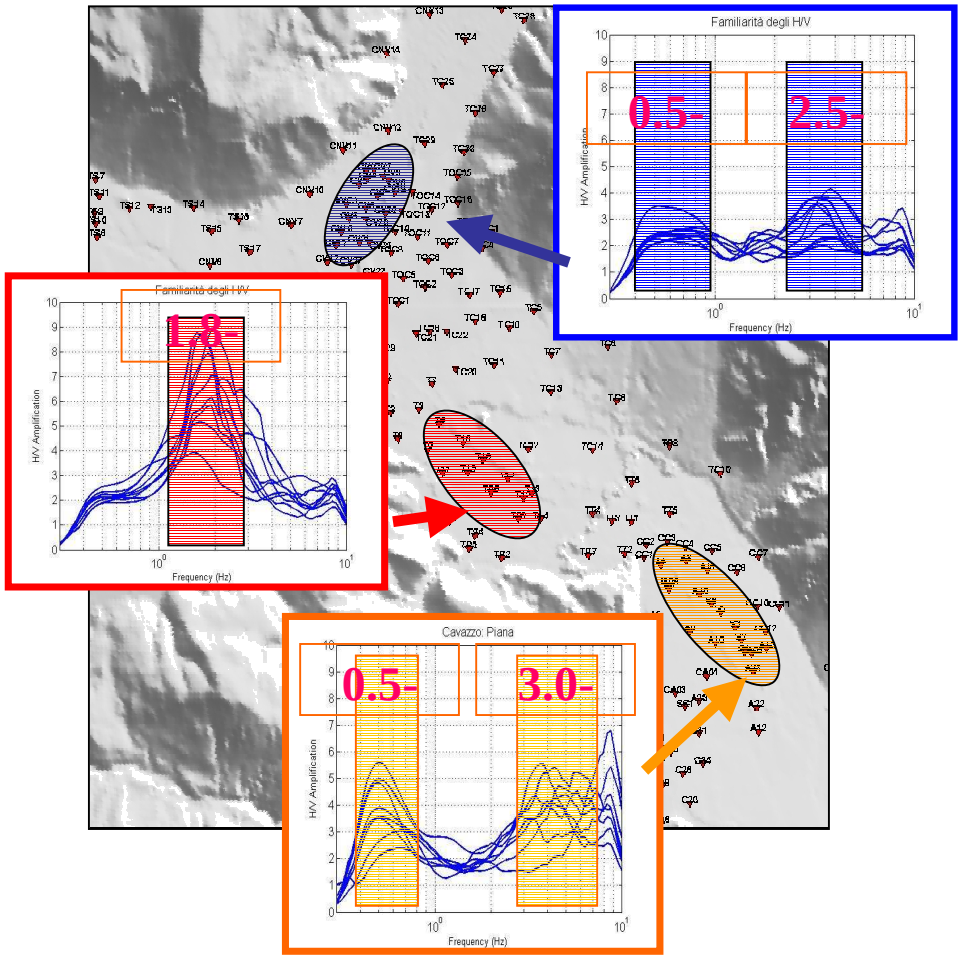

Figure 2: Sorting of the spectral ratios of ambient noise measurements in three different subzones within THV. Panels over the layout map include the H/V frequency intervals (red text) where resonant peaks are identified.

S-wave profiles by analysing the dispersion properties (phase velocities) of the surface waves were carried on three areas having different shallow soils. We derived isotropic shear wave velocity profiles by inverting simultaneously Rayleigh and Love fundamental mode. From a set of possible solution, the final choice was made by computing profiles able to fit the peaks of resonance showed by H/V spectral ratios.
266 microgravimetric measurements were performed in the same area where the ambient noise was recorded to perform a 3-d gravity modelling. In doing that we wanted to exploit the density contrast and to test if it was possible to define the shape of the bedrock from gravimetric measurements. The method used was a well-known method that required as an input a detailed topography, a preliminary regionalization of the density

properties of the different materials and some reference point to constrain the inversion. The density values here assumed were not direct measurements but represented average values obtained by a database specific for the alpine valleys.
Local second order anomalies were the main target. Thus gravimetric data had to be corrected for the first order regional anomaly.
From the gravity inversion was easy to derive the isolines of the elevation of the bedrock and compare the map with the elevation derived by combining the H/V spectral ratio information and shear wave velocities. The consistency between the two maps shown in the Fig. 3 below is pretty good, although the sampling of the area by the two methods is different and in some regions gravity data lack.
Finally for more than 18 months 6 seismic stations recorded the regional seismicity along a transect trough the THV. 545 events were recorded, included the Kobarid M=5.1 event of 12 july 2004. Around 60 events were used to estimate the RSSR at the edges of the valley and at the center. Largest velocity amplification was found for the stations deployed in the center of the valley while at higher frequencies the strongest amplification was found at the edges. A polarization analysis on the raw record showed that at the edges the ground motion is polarised mainly along the horizontal plane while at the reference station on the right and the other stations did not show a preferential polarization.

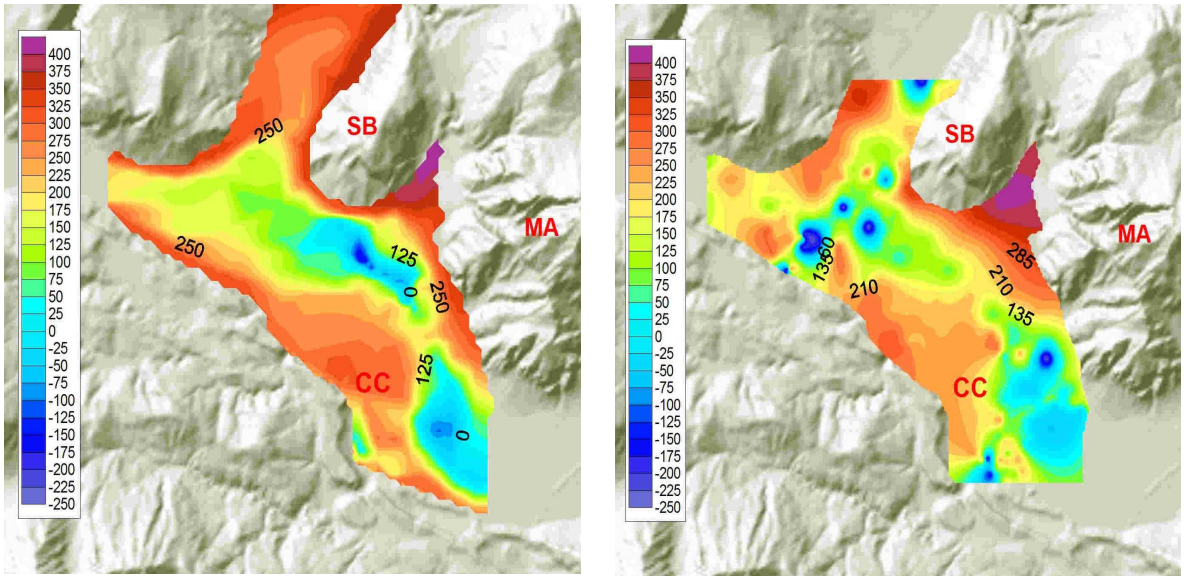

Figure 3: Bedrock elevation isolines by gravity inversion (left panel) and by combining the H/V spectral ratio information and shear wave velocities (right panel). CC = Cavazzo Carnico municipality, SB=Mount Strabut, MA= Mount Amariana.

Which contact did you have through this work with the stakeholders?

A restitution day was held in March 9th 2007 in Tolmezzo between the Italian partners of the SISMOVALP project where, results coming from the new geophysical data and seismic response studies were presented to the local authorities and stakeholders.